Ventricular Tachycardias

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KEYWORDS

• Ventricular tachycardia • Electrocardiographic localization and anatomy
• Electrophysiology mapping • Electroanatomical substrate

KEY POINTS

- Understanding the underlying substrate is critical for preprocedural planning to optimize ablation outcomes and minimize procedural risk.
- Careful analysis of the electrocardiogram pattern is useful for localization of the ventricular tachyarrhythmia site of origin.
- Detailed knowledge of the anatomy is essential for developing mapping and ablation strategies.
- A hybrid approach of both conventional activation-entrainment mapping and substrate characterization is needed for successful ablation.

Ventricular tachyarrhythmia (VT) is an important cause of morbidity and sudden death in patients with structural heart disease. Although implantable cardioverter-defibrillator (ICD) reduces the risk of sudden arrhythmic death,[1,2] ICD therapies have been associated with increased mortality[3,4] as well as a significant negative impact on patients' quality of life.[5,6] Antiarrhythmic drugs, including amiodarone, may be effective in preventing arrhythmia recurrences and ICD therapies but have an increased risk of drug-related adverse effects and noncardiac mortality.[7,8]

In recent years, utilization of VT catheter ablation has increased and evolved.[9,10] This section of the monograph is devoted entirely on ventricular arrhythmias. These cases are uniquely thought provoking, with emphasis on important electrocardiographic and anatomic features, illustrating crucial points in the use of diagnostic maneuvers, mapping techniques, imaging integration, as well as formulating the appropriate ablation strategies.

The right ventricular (RV) and left ventricular (LV) outflow tracts share many similar characteristics because of the common embryonic origin.[11] Identifying the precise arrhythmia location and achieving successful ablation may be challenging because of the complex anatomic relationship and close proximity of various structures. However, several electrocardiographic features can provide clues.[12–16] The utility of 12-lead electrocardiogram (ECG), coupled with a detailed understanding of the anatomy, remains invaluable in localizing such arrhythmia foci. A systematic approach to mapping of outflow tract arrhythmias, along with real-time image guidance, such as intracardiac echocardiography, helps to improve procedural outcome and minimize complications.

Ventricular arrhythmias originating from the aortic noncoronary cusp is rare and usually occurs in young patients. The ECG morphology is often similar to those that arise from the right coronary cusp or para-Hisian locations.[17] Motonaga and colleagues presented such an unusual case and provided an excellent discussion on the complex anatomic relationship between the RV and LV outflow tracts (see: Motonaga K, Ceresnak S, Hsia H. Unusual outflow tract ventricular tachycardia, in this issue).

Ventricular arrhythmias arising from the LV summit may account for up to 18% of the idiopathic arrhythmias from the LV outflow tract.[18] The LV summit represents the most superior portion of the LV, including the epicardial surface bisected by the coronary vasculature. Ablation is often

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limited by the proximity to the coronary arteries and the presence of epicardial fat. Intraoperative imaging is essential to avoid coronary arterial damage,[19] and effective ablation may be achieved from anatomically adjacent sites as an alternative target. Groups from both the University of Pennsylvania and the Brigham and Women's Hospital provided illustrative case studies of such challenging arrhythmia (see: Santangeli P, Lin D, Marchlinski F. Catheter ablation of ventricular arrhythmias arising from the left ventricular summit and Kumar S, Tedrow U, Stevenson W. Ventricular arrhythmias from the left ventricular summit: critical importance of anatomy, imaging and detailed mapping to allow safe and effective ablation, in this issue). Recently, specific electrocardiographic indices have been described that predict ablation success.[20] ECG analysis is, therefore, crucial for planning of the most appropriate mapping approach for LV summit arrhythmias.

Ventricular arrhythmias originating from the cardiac crux represents another unusual arrhythmia that has also been increasingly recognized.[21,22] Laroussi and colleagues presented an idiopathic ventricular tachycardia originating from the LV apical crux region that was mapped and successfully ablated via an epicardial approach (see: Larroussi L, Badhwar N. Ventricular tachycardia arising from cardiac crux: ECG recognition and site of ablation, in this issue). This case highlighted again the importance of ECG analysis in predicting the potential location of the target site.

Nogami and colleagues presented an excellent review of the anatomy and mechanism of fascicular VT. Patients with fascicular VT may not be easily inducible, perhaps because of the subendocardial location of the Purkinje fibers that is vulnerable to catheter trauma during mapping. This case report provided an effective strategy for anatomically based ablation when fascicular VT is noninducible or if diastolic Purkinje potential cannot be recorded during mapping (see: Talib A, Nogami A. Anatomical ablation strategy for non-inducible fascicular tachycardia, in this issue). Pace mapping at the successful ablation site is often not perfect because selective capture of the orthodromic limb of the circuit is difficult and there may be a "lower common pathway" in some patients.

Postinfarction VTs are mostly due to scar-based reentry with nonuniform anisotropic conduction, multiple potential circuits with interconnecting channels. Such scar substrate may be identified by low-voltage recordings as well as the presence of local abnormal ventricular activities (LAVA) or late potentials. Most of the VTs in patients with ischemic heart disease and prior myocardial infarctions can be successfully ablated by an endocardial approach targeting the late potentials/LAVA, which are surrogates for the surviving myocardial bundles. A combination of activation mapping, entrainment, electroanatomical substrate characterization, and pace mapping is required. As illustrated by the case from University of Oklahoma, a systematic approach is essential to improve ablation success and safety (see: Garabelli P, Stavrakis S, Po S. Ablation of ventricular tachycardia in patients with ischemic cardiomyopathy, in this issue).

By contrast, scar in nonischemic cardiomyopathy is commonly located in the midmyocardium or epicardium, associated with smaller areas of endocardial low-voltage abnormalities.[23–26] The subset of patients with predominantly intramural septal scar poses particularly challenges, with high long-term arrhythmia recurrence despite multiple ablations.[27] Nazer and colleagues presented an interesting case of pleomorphic ventricular tachycardia, reflecting variable fusions from multiple exits of a septal VT (see: Nazer B, Hsia H. Pleomorphic ventricular tachycardias in nonischemic cardiomyopathy, in this issue). With careful analysis and patience, an isthmus site of the reentrant circuit was ultimately identified and successfully ablated. The group from University of Colorado presented an unusual patient with biventricular noncompaction with both endocardial and epicardial VTs (see: Gonzalez J, Tzou W, Sauer W, et al. Ventricular tachycardia in a patient with bi-ventricular non-compaction, in this issue). A hybrid approach of conventional mapping techniques coupled with substrate analysis was again required for a successful result. This case highlighted the potential epicardial substrate in patients with uncommon forms of nonischemic cardiomyopathies.

This collection of challenging real-life cases emphasizes several important points about mapping and ablation of ventricular arrhythmias: (1) Careful preprocedural planning based on patients' history and clinical data is essential. Analysis of ECG is critical for localizing the potential arrhythmia foci/substrate and helps to formulate mapping approaches. (2) A detailed understanding of anatomy is important. A strategy of mapping all potential target sites in proximity and the use of an alternative location for ablation energy delivery may be required, particularly for ventricular arrhythmias originating from the LV summit or crux. (3) For scar-based VTs, a systematic approach with a combination of activation mapping, entrainment, and pace mapping as well as detailed substrate characterization are required for a successful outcome. (4) The use of imaging guidance is important to facilitate mapping and to minimize risk/complications.

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